Communication Theory II

Lecture 1: Introduction

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Assistant Professor, Mansoura University, Egypt

* Note that some of the class materials are not developed by the instructor. All the references of these materials are included.

February 8th, 2015

Lecture Outlines

- **Part 1:** About Communication theory II
  - Objectives
  - Course materials
  - Grading and regulations
  - Course contents
- **Part II:** Introduction to digital communication
  - History of communications
  - Block diagram of a digital communication system
  - Advantages and disadvantages of digital communication

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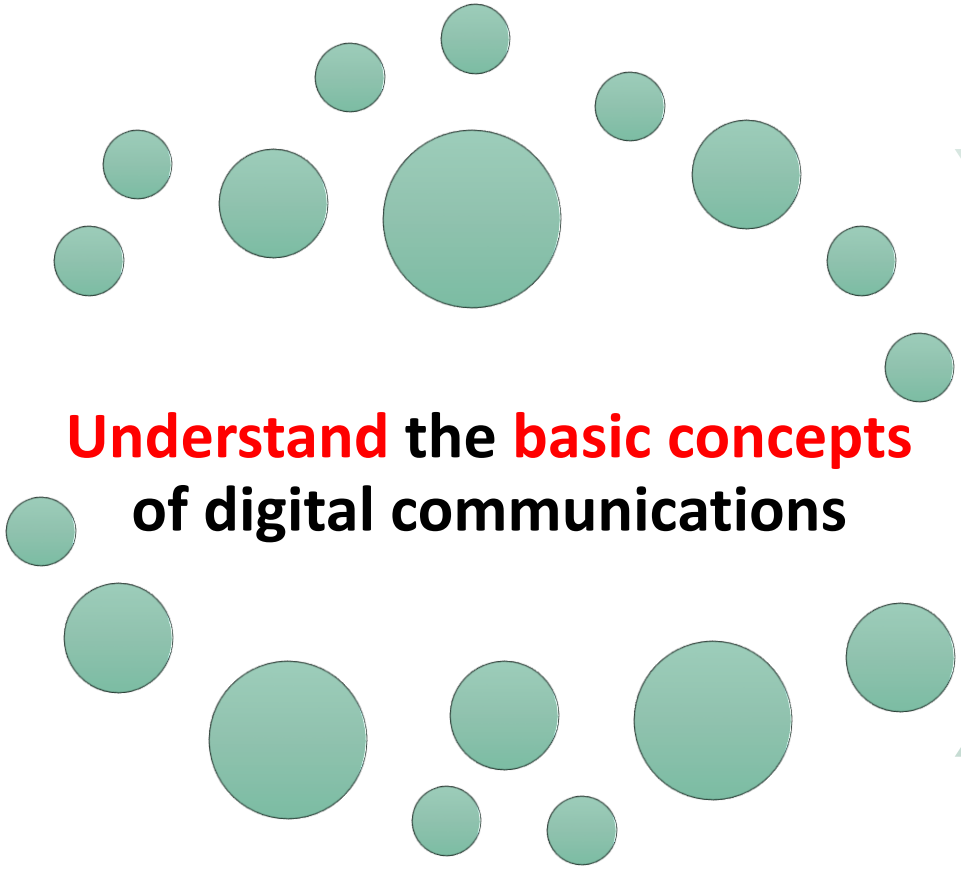
Course Objectives



Understand the **basic concepts** of digital communications

Apply this knowledge to **solve** and **design** solutions for digital communication problems

About the instructor

Current position	Assistant Professor, Mansoura University, 2015		
Professional Training	Post Doctor	University of Louisville, USA	2014
	PHD	University of Louisville, USA	2008-2013
	Master	University of Mansoura	2004-2007
	MSc	University of Mansoura	1998-2003
Research Interests	Medical image analysis, cancer imaging, brain disorders, computer aided diagnosis systems		
More details	Research gate (or) Google scholar: Ahmed Elnakib		

Required Course Materials

Text books	• B. P. Lathi and Zhi Ding, "**Modern Digital and Analog Communication Systems, 4th Edition**" (Oxford Series in Electrical and Computer Engineering), 2009. • Robert G. Gallager, "**Principles of Digital Communication**," Cambridge University Press, 2008**.**
Software	MATLAB
Other materials	MIT Course Number 6.450: Principles of Digital Communications I http://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-450-principles-of-digital-communications-i-fall-2006/index.htm

Lectures and office hours

Class Time	Sunday, Thursday- 10:10 am–11:40 pm
Instructor	Ahmed Elnakib, Ph.D.
Office	EC Dept. – Second floor, Room B3119
E-Mail	eng.nakib@gmail.com
Office Hours	11:40 pm–12:40 pm Wednesday or by appointment (email)

Grading

Assessment Method	Weights	Time
Mid Term Examination	14%	Week 7
Oral Examination	7%	Week 12
Semester work	13%	Every week
Final Term Examination	66%	Week 14
Total	100%	

Regulations

- Attendance of lectures and sections are mandatory
- Be ready for any questions during the section or the lecture
- Outside courses are useless
  - Work hard
  - Test you self: rely on your self and be independent
  - Invest in your self

Course Contents*

- Introduction to digital communication systems and Probability theory
- Waveform Coding Systems
- Base Band PCM transmission and probability of error
- Information Theory, Coding, and Channel Capacity
- Channel Coding for Error Detection and Correction
- Digital Modulation/Demodulation
- Spread spectrum communication
- Satellite Communications

* 10% flexibility

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Statistics

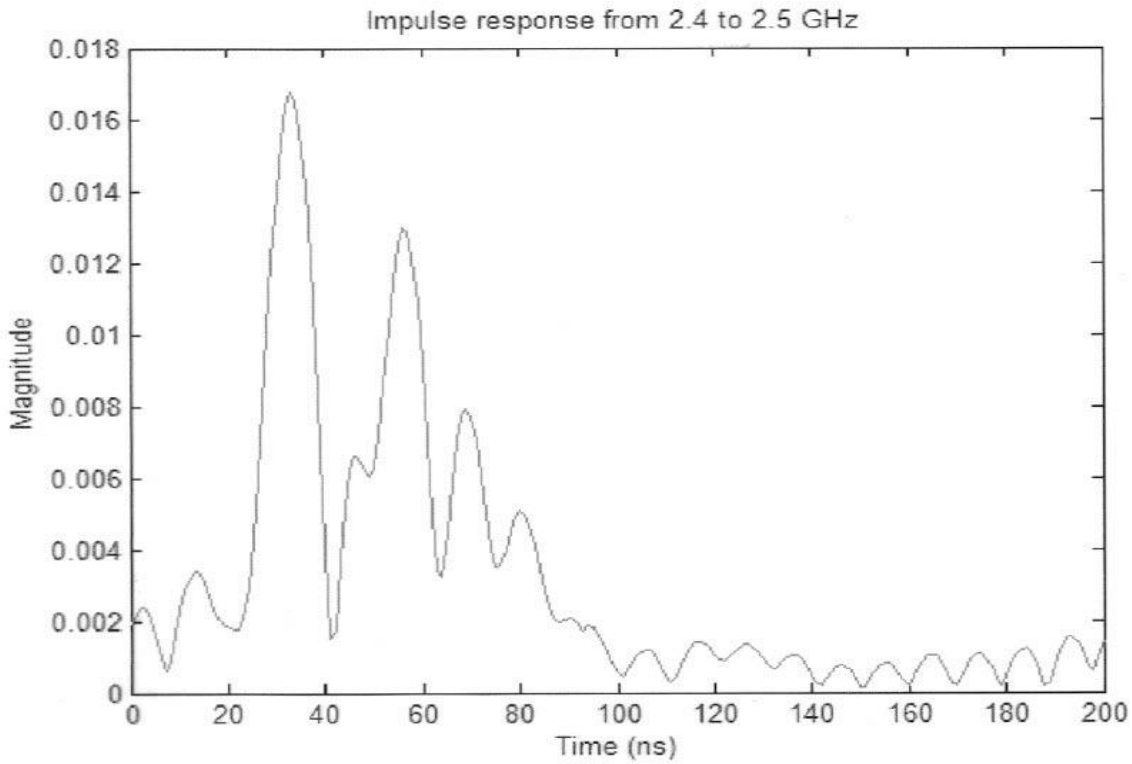
- Etisalat was able to hit the 1 million subscribers mark only 50 days after launching on April 30, 2007.
- As of November 30, 2012, Etisalat has about 24.5 active subscribers from almost 95.5 million mobile subscribers in Egypt
- During an interview with Daily News Egypt, Abdel Mohsen said that, on a monthly basis, the smartphones market sales are at 50,000 phone
- During 2011, smartphones in use were barely at 500,000 devices. Right now, sold smartphones in the local market are at 6.5m phones

History of communications*

- Software
- Hardware
- Communication architecture, with coding and signal processing algorithms

* David Tse, “A brief history of communications,” Stanford University. https://web.stanford.edu/~dn**tse**/presentations/hkn_talk.ppt

Communication channels can be very nasty!



Channel distortion, noise, interference……

How do we communicate reliably over such channels?

Communication has a long history

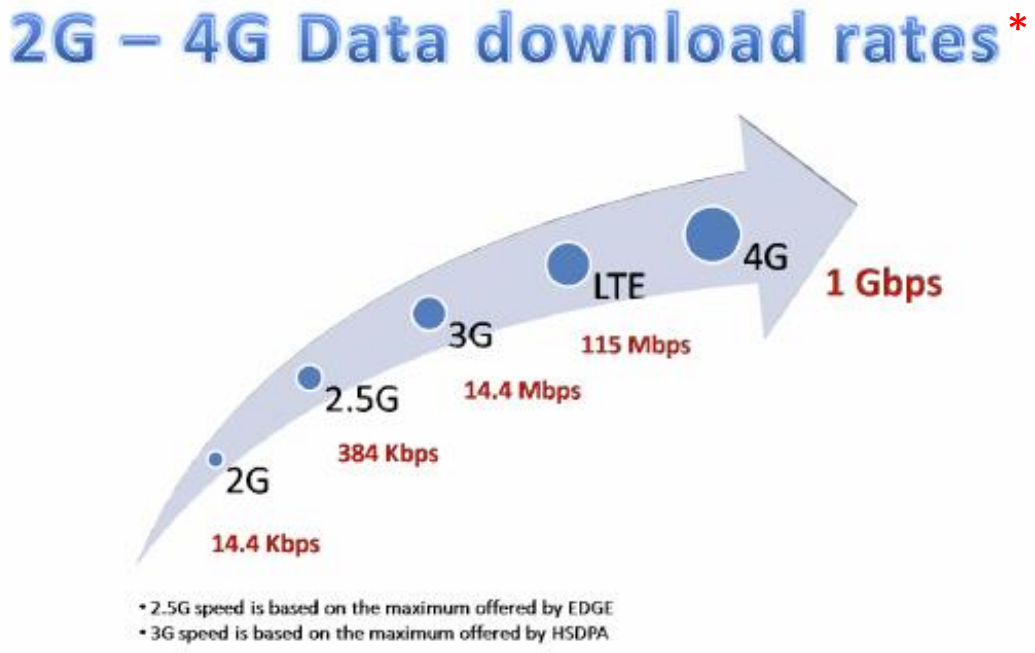
- **150 BC:** Smoke signals
- **1792:** Optical Telegraph
- **1876:** telephone by Alexander Graham Bell
- **1895:** invention of the radio by Marconi
- **1901:** trans-atlantic communication

State of affairs: Early 20th century

- Most communication systems are analog
- Engineering designs are ad-hoc, tailored for each specific application

Big Questions

- Is there a general methodology for designing communication systems?
- Is there a limit to how fast one can communicate?



* Image courtesy: *Mobile Handset Cellular Network: GSM (2G), 3G, and 4G (LTE), 2G_3G_4G_Tutorial.ppt*

Harry Nyquist (1928)

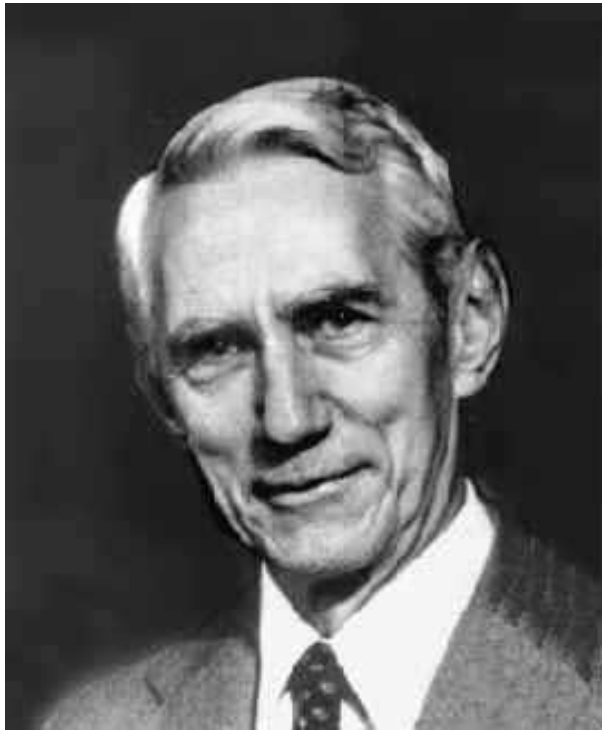
- Analog signals of bandwidth W can be represented by 2W samples/s
- Channels of bandwidth W support transmission of 2W symbols/s

From CT to DT

- Nyquist converted the continuous-time problem to a discrete-time problem.
- But has he really solved the communication problem?
  - No. You can communicate infinite number of bits in one continuous-valued symbol!

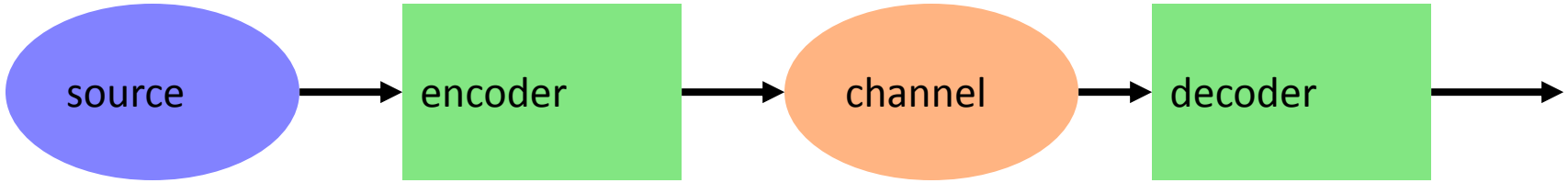
Claude Shannon (1948)

- His information theory addressed all the big questions in a single stroke



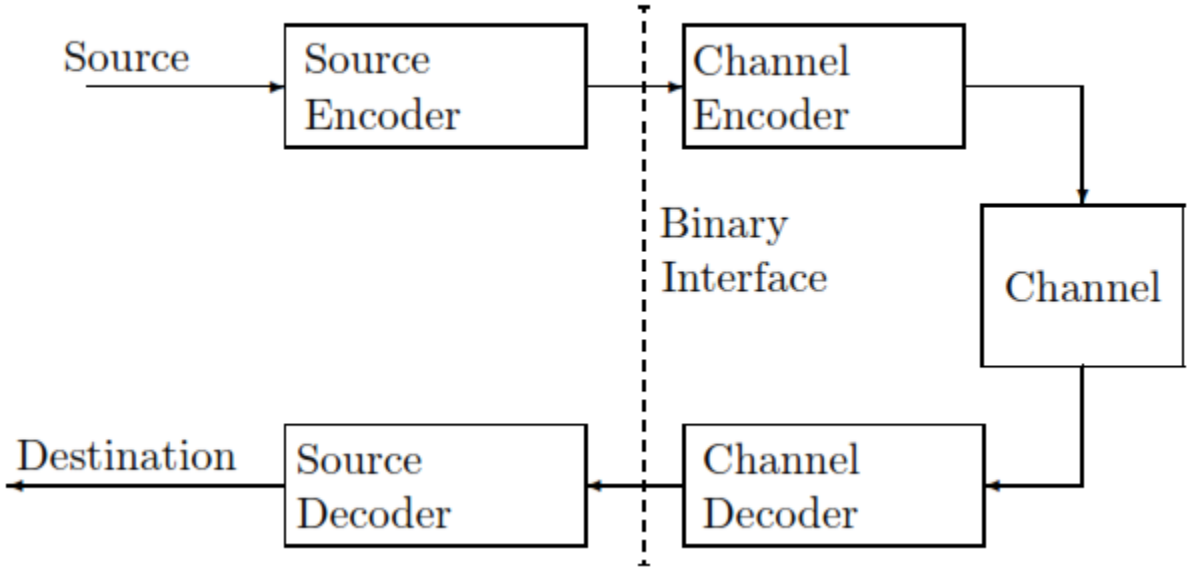
Randomness

Shannon thought of both information sources and channels as random and used probability models for them



Everything is bits

Shannon showed the universality of a digital interface between the source and the channel.



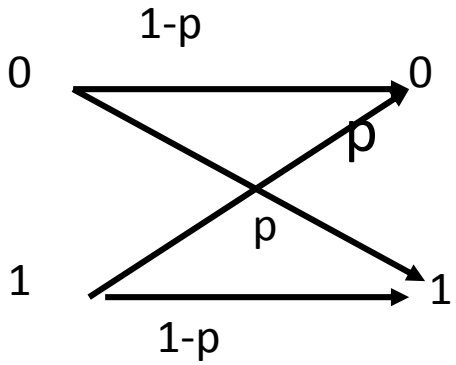
Digital communication systems are communication systems that use such a digital sequence as an interface between the source and the channel input (and similarly between the channel output and final destination)*.

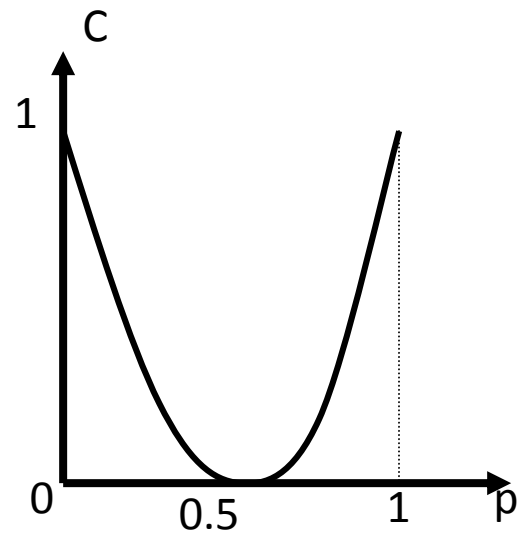
**MIT Course Number 6.450: Principles of Digital Communications I*

Information is like fluid

- Every source has an entropy rate (source information rate) H bits per second
- Every channel has a capacity C bits per second
- Reliable communication is possible if and only if $H < C$

Simple example: binary symmetric channel





$$C = 1 + p \log p + (1-p) \log (1-p)$$

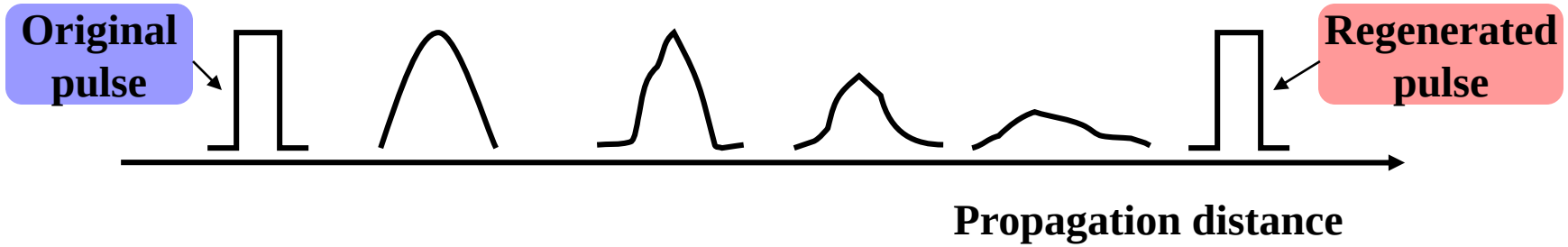
Initial Reactions

Engineers didn’t understand what he was talking about.

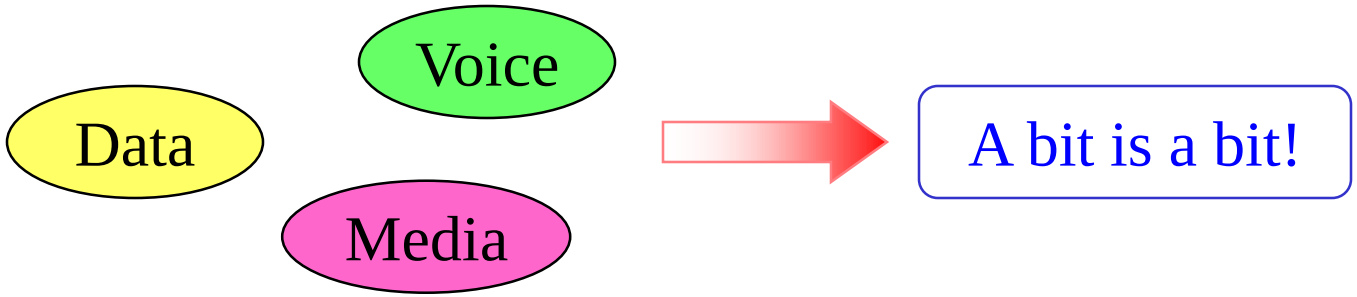
- People were still stuck in the analog world
- Complexity way too high for implementation technology of the day
- He didn’t really tell people exactly how to design optimal communication systems.

Why Digital Communications*

- Regenerator receiver



- Different kinds of digital signal are treated identically



*Yewen Cao, "*Principle of Communications*," Shandong University

Why Digital Communications (Cont'd)

- Error detection and correction, e.g., parity bit
- Security and Encryption
- Simple TDM (Switches/software)/ Code division Multiplexing (CDM)
- Digital processing of data, e.g., compression
- Ultrahigh integration on smaller and faster IC and processors

Cost of Digital Communications

- Increased BW
  - Frequency of sampling ≥ 2 analog bandwidth
  - Number of bits per symbol
- Increased Synchronization complexity
  - Word Clock
  - Bit Clock

50 years later….

- Our communication infrastructure is going fully digital.
- Most modern communication systems are designed according to the principles laid down by Shannon.

Pager
• receive only
• tiny displays
• simple text messages

PDA (Personal Digital assistance)
• simple graphical displays
• character recognition

Laptop
• fully functional
• standard applications

Tablets
• fully functional
•standard applications

Sensors, embedded controllers

Mobile phones
• voice, data
• simple text displays

Palmtop
• tiny keyboard
• simple versions of standard applications

Smartphone
• fully functional
•standard applications

Questions